

Attachment A

Comparison of Occupational Fatality and Injury Risks for Sed-6 vs. Sed-4

Methods for estimating the occupational risks of worker fatalities and injuries have been published by Leigh and Hoskin (1999), Hoskin *et al.* (1994), and Cohen *et al.* (1997). These methods rely upon actuarial statistics of worker fatalities and injuries published by the Bureau of Labor Statistics (BLS). In contrast, the baseline human health risks are the *hypothetical* health risks associated with exposure to site-specific contaminants.¹

To estimate the occupational risks for the sediment remedial alternatives Sed-4 and Sed-6, it is necessary to estimate the labor (hours) required for each alternative. For each of the remedy components for these alternatives, URS prepared estimates of the labor required based on the cost estimates presented in the Feasibility Study (FS) report (also prepared by URS). Note that each of these remedial alternatives has a "contingency" cost of 20% applied to the remedial costs to account for uncertainty in the costs (excluding engineering and oversight, which are separate line item costs). To account for this contingency, the labor associated with the "base" cost of each alternative was increased by a total of 20% and added to the respective "base" labor allocation to each line item in proportion to the fraction of overall labor for each individual component. Table A.1 summarizes the labor estimates for Sed-4 *versus* Sed-6.

Occupational fatalities and injury rates vary depending on occupational labor categories. The labor categories we used correspond to the Means Labor categories and parallel those used by Hoskin *et al.* (1994) and Leigh and Hoskin (1999). Occupational fatalities, injuries, and employment statistics were obtained from the BLS (2009).

Fatality and employment job categories were matched by occupation code to obtain an annual fatality rate per 10,000 workers by job category as follows:

$$\text{Fatality Rate [per 10,000]} = \frac{\text{Total Fatalities}}{\text{Total Employed}} \times 10,000$$

Occupational fatalities and employment by labor categories were based on BLS 2003 data (which contain data for both components).

The BLS typically publishes injury statistics by industry, rather than occupational categories. A 2004 BLS Report published injury statistics by broad occupational categories, as well as those occupational categories with the leading injury rates, some of which are those required for the Record of

¹ Note that this is the risk of contracting cancer, not mortality from cancer. In contrast, the fatality risk is the chance of mortality due to a work-related accident.

Decision (ROD) remedy. Using these data, injury rates by job category were calculated in a manner similar to the fatality rates:

$$\text{Injury Rate [per 10,000]} = \frac{\text{Total Injuries}}{\text{Total Employed}} \times 10,000$$

The fatality and injury rates are summarized in Table A.2. As this summary shows, the incidence rates vary by job category, with the transportation and construction laborer categories carrying the highest risks.

Following the method of Hoskin *et al.* (1994), multiplying the annual fatality or injury rates for each job category by the percentage of labor hours required for each, gives the weighted average fatality or injury rate. This total weighted fatality rate was 2.5 per 10,000 workers per year, which is similar to the value of 3.5 per 10,000 developed by Hoskin *et al.* (1994). Hoskin's value is higher primarily due to the fact that the Hoskin *et al.* estimate is based on a hypothetical remedy involving a far higher percentage of hours associated with transportation, 80% compared to the estimate here of 18%.

Injury rates are nearly 100-fold higher than death associated with accidents, which is not a surprising result. Some fraction of the injuries is considered "disabling," whereas others are associated with sickness or other health-related issues. The BLS statistics do not separate disabling injuries, so it was not possible to quantify the distinction between disabling and non-disabling injuries.

A summary of the short-term risks associated with Sed-4 *versus* Sed-6 is provided in Table A.3. Following the method of Leigh and Hoskin (2000), the probability of at least one fatality (P) is estimated using a Poisson distribution, where the probability is given by $P = 1 - e^{-\mu}$, where μ is the risk of fatality.

Table A.1
Labor Hour Estimate Summary Sheet
Ashland/Northern States Power Lakefront Superfund Site, WI

Alternative Sed-4	Cost	Labor	Labor	Contingency	Totals	Labor Category assigned	
	(\$)	(hrs)	(% of total)	(hrs)	(hrs)		
Mob/Demob & Miscellaneous	\$2,400,000	32,100	16%	7,780	39,880	11.1%	Construction Laborer/Equip Operator
Dredge & Sediment Handling	\$19,500,000	92,500	46%	22,420	114,920	32.0%	Construction Laborer/Equip Operator
Water Treatment	\$10,100,000	6,000	3%	1,454	7,454	2.1%	Chemist
Transport and Disposal	\$4,400,000	52,000	26%	12,604	64,604	18.0%	Trucking
Long-Term Monitoring	\$700,000	17,500	9%	4,242	21,742	6.1%	Chemist
Subtotal		200,100					
Engineering @ 15% ⁽¹⁾	\$5,500,000	48,500			48,500	13.5%	Engineer
Oversight @ 15% ⁽²⁾	\$5,500,000	61,800			61,800	17.2%	Foreman
Contingency @ 20% ⁽³⁾	\$7,300,000			48,500			
Totals	\$55,300,000	310,400		48,500	358,900	100%	
Alternative Sed-6	Cost	Labor	Labor	Contingency	Totals	Labor Category assigned	
	(\$)	(hrs)	(% of total)	(hrs)	(hrs)		
Mob/Demob & Miscellaneous	\$2,600,000	41,900	17%	10,326	52,226	11.7%	Construction Laborer/Equip Operator
Dredge & Sediment Handling	\$28,100,000	109,700	45%	27,035	136,735	30.7%	Construction Laborer/Equip Operator
Water Treatment	\$9,600,000	14,100	6%	3,475	17,575	3.9%	Chemist
Transport and Disposal	\$5,200,000	63,100	26%	15,551	78,651	17.7%	Trucking
Long Term Monitoring	\$700,000	17,500	7%	4,313	21,813	4.9%	Chemist
Subtotal		246,300					
Engineering @ 15% ⁽¹⁾	\$6,800,000	60,700			60,700	13.6%	Engineer
Oversight @ 15% ⁽²⁾	\$6,800,000	77,400			77,400	17.4%	Foreman
Contingency @ 20% ⁽³⁾	\$9,100,000			60,700			
Totals ⁽⁴⁾	\$69,000,000	384,400		60,700	445,100	100%	

Notes: 1 = 67% of the cost was assumed to be labor at \$75/hour for the Engineering labor hour estimate

2 = 85% of the cost was assumed to be labor at \$75/hour for the Oversight labor hour estimate

3 = 50% of the cost was assumed to be labor at \$75/hour for the Contingency labor hour estimate

4 = Option 6 work items that account for the higher cost and labor hours as compared to Option 4 includes installing land-side sheet pile walls, constructing and operating the groundwater collection trench system, installing the wave attenuator, and excavating the near-shore sediments in a relatively dry state.

Table A.2
Comparison of Occupational Fatalities and Injuries for Sediment Remediation Alternatives
Ashland/Northern States Power Lakefront Superfund Site, WI

Labor Remedy ^[a]			Fatal Occupational Injuries in US (2003)				Non-Fatal Occupational Injuries in US (2004)				Fatalities / Injuries By ROD Labor Category	
Occupational Category ^[b]	Estimated Labor Hours	Percentage distribution of hours	Occupation Code ^[c]	Total Employed	Annual Fatalities	Annual Fatality Rate (per 10,000)	Occupation Code	Total Employed	Annual Injuries	Annual Injury Rate (per 10,000)	Fatalities (per 10,000)	Injuries (per 10,000)
	(1)					(2)				(3)	(1) x (2)	(1) x (3)
<i>SED-4</i>												
Civil Engineer	46,657	13%	17-2051	211,280	4	0.19	17-0000 ^[d]	2,385,680	6,960	29.2	0.0246	3.79
Field Chemist (technician)	25,123	7%	19-4031	61,870	4	0.65	19-0000 ^[d]	1,144,240	3,130	27.4	0.0453	1.91
Foreman	61,013	17%	47-1011	518,660	112	2.16	47-0000 ^[d]	6,303,180	144,050	228.5	0.3671	38.85
Construction Laborer	78,958	22%	47-2061	845,890	290	3.43	47-2061	892,940	37,930	424.8	0.7542	93.45
Equipment Operator	82,547	23%	47-2073	343,600	63	1.83	47-0000 ^[d]	6,303,180	144,050	228.5	0.4217	52.56
Truck Driver (heavy/trucks)	64,602	18%	53-3032	1,520,740	722	4.75	53-3032	1,594,980	63,570	398.6	0.8546	71.74
Totals	358,900	100.0%		3,502,040	1,195	3.41		18,624,200	399,690	214.61	2.5	262.31
Equivalent Worker Years (8 hr/day, 250 days/yr)	179									Expected Fatalities/Injuries for Remedy:	0.044	4.71
General Construction and Extraction Occupations			47-0000	6,099,360	1,038	1.7	47-0000	6,303,180	144,050	228.5	0.031	4.101
Transportation and Material Moving Occupations			53-0000	9,361,690	1,393	1.5	53-0000	9,597,380	257,210	268.0	0.027	4.809
<i>SED-6</i>												
Civil Engineer	46,657	13%	17-2051	211,280	4	0.19	17-0000 ^[d]	2,385,680	6,960	29.2	0.0246	3.79
Field Chemist (technician)	25,123	7%	19-4031	61,870	4	0.65	19-0000 ^[d]	1,144,240	3,130	27.4	0.0453	1.91
Foreman	61,013	17%	47-1011	518,660	112	2.16	47-0000 ^[d]	6,303,180	144,050	228.5	0.3671	38.85
Construction Laborer	78,958	22%	47-2061	845,890	290	3.43	47-2061	892,940	37,930	424.8	0.7542	93.45
Equipment Operator	82,547	23%	47-2073	343,600	63	1.83	47-0000 ^[d]	6,303,180	144,050	228.5	0.4217	52.56
Truck Driver (heavy/trucks)	64,602	18%	53-3032	1,520,740	722	4.75	53-3032	1,594,980	63,570	398.6	0.8546	71.74
Totals	445,100	100.0%		3,502,040	1,195	3.41		18,624,200	399,690	214.61	2.5	262.31
Equivalent Worker Years (8 hr/day, 250 days/yr)	223									Expected Fatalities/Injuries for Remedy:	0.055	5.84
General Construction and Extraction Occupations			47-0000	6,099,360	1,038	1.7	47-0000	6,303,180	144,050	228.5	0.038	5.086
Transportation and Material Moving Occupations			53-0000	9,361,690	1,393	1.5	53-0000	9,597,380	257,210	268.0	0.033	5.964

Notes: [a] Overall Labor estimates provided by URS.
[b] Occupational Categories adopted based on those in Hoskin et al., 1994.
[c] Occupational codes from Bureau of Labor Statistics annual employment tables.
[d] No injury data available for particular labor category – values used are for the occupation as a whole.
Occupation 2-digit prefix: 17 - Architecture and Engineering; 19 - Life, Physical, and Social Sciences; 33 - Protective Services; 47 - Construction and Extraction, 53 - Transportation and Material Moving.

Table A.3 Summary of Worker Fatality and Injury Risks for Sed-4 vs. Sed-6			
Risk Category	Sed-4	Sed-6	Increased Risk
Risk of Fatality	4.4×10^{-2}	5.5×10^{-2}	23%
Probability of at Least One Fatality	4.3%	5.3%	23%
Estimated Number of Injuries	4.7	5.8	23%
Baseline Human Health (Chemical) Risk	1×10^{-5} (adult wader)		

For perspective, the human health risk of exposure to sediment-related contamination presented in the PRAP is 1×10^{-5} . Thus the actuarial risk of incurring a fatality during the remedy far exceeds the potential cancer risk associated with chemical exposure. Furthermore, chemical risks represent the risk of cancer, not death. If these risks are weighted by the "Years of Potential Life Lost," or YPLL, then the actuarial risks associated with worker fatalities are even more severe than the hypothetical cancer risks. In a paper by Cohen *et al.* (1997), a worker fatality is expected to result in 32.4 years of lost life (this is a function of the age distribution of workers), whereas cancer risks are expected to yield approximately 15 years of lost life (*e.g.*, cancers typically manifest themselves later in life). Thus, when viewed from the standpoint of which risk carries with it the largest decrease in expected lifespan, the worker fatality risk projected for the project, on average, is associated with a greater decrement in life expectancy (twofold decrease) relative to the risk of mortality from cancer.

The NCP requires an evaluation of alternatives relative to short-term effectiveness (*e.g.*, risks), yet no such analysis was performed in the PRAP. The PRAP indicates that both the Sed-4 and Sed-6 remedies are protective of human health and the environment, and both satisfy the NCP Threshold Criteria. Yet on the basis of the short-term effectiveness Balancing Criteria, the Sed-4 is clearly superior to the Sed-6 alternative. Thus, the selection of Sed-6 as the recommended remedy is contrary to the NCP and CERCLA.

References

Cohen, JT; Beck, BD; Rudel, R. 1997. "Life years lost at hazardous waste sites: Remediation worker fatalities vs. cancer deaths to nearby residents." *Risk Anal.* 17(4):419-425.

Hoskin, AF; Leigh, JP; Planek, TW. 1994. "Estimated risk of occupational fatalities associated with hazardous waste site remediation." *Risk Anal.* 14(6):1011-1017.

Leigh, JP; Hoskin, A. 1999. "Hazards for nearby residents and cleanup workers of waste sites." *J. Occup. Environ. Med.* 41:331-348.

Leigh, JP; Hoskin, AF. 2000. "Remediation of contaminated sediments: a comparative analysis of risks to residents vs. remedial workers." *Soil and Sediment Contamination* 9(3):291-309.

US Department of Labor, Bureau of Labor Statistics (BLS). 2009. "Bureau of Labor Statistics Web Site." Accessed at <http://www.bls.gov/>.

US Department of Labor, Bureau of Labor Statistics (BLS). 2003a. "Census of Fatal Occupational Injuries (revised data), Table A-5: Fatal occupational injuries by occupation and event or exposure, All United States, 2003." Accessed at <http://www.bls.gov/iif/oshwc/cfoi/cftb0191.pdf>.

US Department of Labor, Bureau of Labor Statistics (BLS). 2003b. "Occupational Employment and Wage Estimates National Cross-Industry Estimates." Accessed at http://www.bls.gov/oes/oes_dl.htm#2003_n. November

US Department of Labor, Bureau of Labor Statistics (BLS). 2004a. "Lost-Worktime Injuries And Illnesses: Characteristics And Resulting Time Away From Work, 2004." Accessed at <http://www.bls.gov/news.release/pdf/osh2.pdf>.

US Department of Labor, Bureau of Labor Statistics (BLS). 2004b. "Occupational Employment and Wage Estimates National Cross-Industry Estimate." Accessed at http://www.bls.gov/oes/oes_dl.htm#2004_n. November.

US Department of Labor, Bureau of Labor Statistics (BLS). 2004c. "Table 3. Number of nonfatal occupational injuries and illnesses involving days away from work by major occupational group and major industry sector, 2004."

US Department of Labor, Bureau of Labor Statistics (BLS). 2004d. "Table 4. Number of nonfatal occupational injuries and illnesses involving days away from work by selected worker occupation and major industry sector, 2004."

US Environmental Protection Agency (US EPA). 1990. "National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule." *Fed. Reg.* 55 (46):8666-8866.

Attachment B

**Air Emissions Modeling
for Sed-4 and Sed-6 Remedial Alternatives**

To conduct an evaluation of the potential for dispersion of volatile contaminants during sediment remediation, bench scale air emission testing and dispersion modeling were conducted on sediment samples collected from the Ashland/NSP Lakefront Superfund Site (Site). The testing protocol followed the United States Environmental Protection Agency (EPA)-approved Treatability Study Work Plan (URS, 2007). Results of this evaluation were presented in the Feasibility Study (FS) Report and considered in the selection of the preferred remedial alternative for sediment (URS, 2008). Emissions testing on the sediment samples were designed to simulate potential emission rates associated with dredging operations, sediment dewatering, and exposed sediment stockpiling.

The results of the bench scale emissions testing were used in air dispersion modeling to evaluate how volatilized contaminants would be dispersed under simulated remedial alternatives. In particular, modeling was conducted to determine whether human receptors outside of the immediate Site work zones would be exposed to volatile emissions that exceeded odor thresholds and/or risk-based air quality criteria during remedial activities. The EPA AERMOD model (version 07026) was used for this modeling assessment.

Since the dry excavation alternative (Alternative Sed-6) was added at the request of EPA later in the FS review process, air dispersion modeling of Sed-6 was not included in this initial evaluation in the FS. Under Alternative Sed-6 the area within approximately 200 ft of shore would be dewatered and dry excavated; areas further offshore would be dredged. Air dispersion modeling based upon the Sed-6 scenario has now been conducted following the same protocol as in the EPA-approved Treatability Study (TS) in Appendix B2 of the FS. This evaluation compares benzene emissions and odor dispersion for Sed-4 and Sed-6 alternatives.

Volatilization directly from exposed saturated sediment has been found to have a faster rate than volatilization that could occur from first dissolving volatile organic compounds (VOCs) from the sediment to the water and then from the water to air boundary. Dewatering a portion of the bay exposes the sediments and contaminants to the air and volatilization can occur as long as the area is exposed even if not actively being excavated. In addition for Sed-6, removing the overlying water for excavation does not dry out the sediments, which remain saturated during the excavation. A significant increase in emissions between saturated sediment and dredge area suspension was also measured in the Data Gap Report for the St. Louis River/Interlake/Duluth Tar Site (SERVICE, 2002) from sediments contaminated by coal tars that also contained benzene. Emissions data were tested for sediments with 45% solids representing *in situ* conditions of exposed sediment and 1% solids slurry representing the conditions

around a wet dredge. The benzene emission results were 307 $\mu\text{g}/\text{m}^2\text{-hr}$ for the dredge simulation compared to 1,920 $\mu\text{g}/\text{m}^2\text{-hr}$ for exposed sediment or approximately a sixfold increase in the short-term emissions rate. This increase is also apparent in the Ashland site sediment air tunnel testing in the TS when comparing the 1% mixed sediment emission benzene results that simulate the wet dredging activity to the exposed sediment emissions benzene test results. The results from the TS measured the emission rate for representing the wet dredging activity at 83,213 $\mu\text{g}/\text{m}^2\text{-hr}$ compared to the exposed sediment emission rate of 141,457 $\mu\text{g}/\text{m}^2\text{-hr}$ in Area 2/2A, a nearly twofold increase.

Emissions Modeling Methodology

In the FS, the modeling conducted for Alternative Sed-4 (dredging) was based on successive dredging of 100 ft \times 100 ft "cells" at a rate of from one to four days for each cell. The portion of the bay to be remediated was divided into 42 cells and cell 15 (where benzene concentrations in sediment were greatest) was used as the active cell for the model. The model simulated active dredging in cell 15; the remaining 41 cells assumed that emissions were occurring at a background rate. In addition, in the initial evaluation of the emissions in the TS from the onshore work areas were included.

Modeling for the Sed-6 Alternative was based upon similar assumptions for the 42 cells in the remedial area. However, under the Sed-6 Alternative, 24 of those cells would be dewatered by removing the overlying water to facilitate dry excavation methods. Figure B.1 depicts the 24 dewatered cells in yellow/orange and the remaining 18 cells where sediments would be dredged in light green.

In this updated evaluation, modeled benzene emissions from each of the cells were calculated in a similar fashion as was originally done for Alternative Sed-4 in that the active cell (assumed to be cell 15) was used to simulate emissions from cells that would actually be dredged, 42 cells under Sed-4 and 18 cells under Sed-6. For the remaining 24 cells in the dewatered areas under Sed-6, emissions were based on volatilization from wet sediment not covered by water, a rate similar to what had previously been used for wet stockpiles onshore. Emissions from onshore activities, *i.e.*, dewatering and stockpile areas, were not included in this evaluation as they were assumed to be similar. The objective here is to compare the two different sediment removal methods and not to include the uncontrolled emissions on shore that may include some type of controls and different sediment treatment options. However, additional model runs were made to determine the aggregate impact to all receptor points within the model with similar

sediment treatment that excludes the on-site thermal treatment option. The modeled benzene emission rates for Alternative Sed-4 and Alternative Sed-6 are summarized in Table B.1.

This simulation was based upon modeling for benzene for both Sed-6 and Sed-4 alternatives and run for the maximum construction period of activity (May – October) so that maximum predicted concentrations could be calculated and compared. Additional model runs were made for the period of August to October to examine seasonal variability. Only the dredging and excavation operations were initially modeled to show a direct comparison. All of the modeling used the same five-year meteorological record from 2002 to 2006 for Ashland airport that was used in the TS.

To assess the potential impact from odors released during Alternatives Sed-4 and Sed-6, the results of the odor testing from the TS were applied to the modeling conducted for the two different remediation alternatives. These odors may be directly associated with the contaminants, *i.e.*, the volatilized contaminants cause the odor, or the odors may result from the release of natural materials such as hydrogen sulfide. Odor prediction is difficult given the tenuous nature of the scent and the differences in population perception to any given odor. Odor typically has a very short duration response time and therefore can be difficult to model with standard steady-state approximations, such as those used in AERMOD. However, modeling can identify the likelihood that detectable recognizable odors will be associated with certain remedial activities and this was the intent of the comparison. Values corresponding to the odor detection threshold (DT) were not used for this modeling effort and only the recognition threshold (RT) values were used. During the odor testing from the wind tunnel test in the TS, the odor testing assessor panel was required to select one of three forced responses – "guess," "detection," or "recognition." Since the greatest response to nuisance odors by the public will be from recognition, only the RT values were modeled for this comparison. A value of 1.0 odor unit (OU) RT represents the threshold when most people will recognize the odor. A value of 2.0 OU represents a concentration that is twice the RT. The maximum 1-hour OU values were modeled for the two remediation alternatives by converting to OU and using benzene dispersion modeling with a correction factor. This correction factor is based on the test results in the TS for Area 2A sediments for 10% mixed sample during the 2- to 6-hour timeframe for both benzene and RT OU. The RT value of 100 OU and benzene value of 80,519 $\mu\text{g}/\text{m}^2\text{-hr}$ from this testing were used for calculating a ratio that was then used as the correction factor. The modeling results represent the odor plume areas for the alternatives without any onshore activities to allow direct comparison of wet dredging and dry excavation.

Results

Isoconcentration lines for 24-hour benzene concentrations were developed for both Sed-4 and Sed-6 Alternatives. A direct comparison of the 1/10th TLV¹ value of 160 µg/m³ for these two alternatives is provided in Figure B.2 showing the larger extent of the Sed-6 *vs.* Sed-4 Alternative impacts. As discussed above this comparison does not include the onshore activity emissions.

The inclusion of onshore activities in this evaluation is expected to increase both the magnitude and extent of the impacts. When emissions from onshore activities are included, the maximum 24-hour average benzene concentrations associated with the Sed-6 Alternative increase about 13% over the maximum 24-hour average Sed-4 Alternative benzene concentrations for all points within the modeled grid for the May to October modeled timeframe (five years of simulations). An even greater increase is found for running the model with a shorter period from August to October, during which timeframe there is an increase of nearly 45% in Alternative Sed-6 *versus* Alternative Sed-4 maximum 24-hour benzene concentrations. The reason for the difference in these two periods is that during the early summer months of May to July when air is warmer, there is more air mixing than during the cooler temperatures of August to October. Increased atmospheric mixing results in lower concentrations of benzene through dilution during the early summer period when compared to the August to October period of less mixing.

Odor levels were calculated for the 1-hour averaging periods as odor is more transient in nature and subject to shorter duration fluctuations. This modeled run excludes the onshore dewatering and related sediment processing to compare the odor plumes of the wet dredging and dry excavation options. The odor recognition threshold levels are graphically displayed in Figure B.3 for both Sed-4 and Sed-6. Only the 1 OU and 2 OU values are plotted in this figure. As can be seen, Alternative Sed-6 has a greater potential to cause odor dispersion over a larger area for both the 1 OU and 2 OU RT values. Considering the large and lengthy exposure of the sediment for the Sed-6 alternative, more frequent odor incursions are likely within the Ashland area *versus* the likely odor effects associated with Sed-4. The additional time of remediation of one to two or more years required for Sed-6 increases this potential for more odor incursions.

¹ Benzene does not have a specific ambient threshold value; however, it does have an annual averaging period listed in the WDNR regulation (Table A, NR 445.07). The WDNR air toxic rule discusses the possibility of using a 10% adjustment to a Threshold Limit Value (TLV; benzene TLV is 1,600 µg/m³) for a chemical listed with a 24-hour averaging period. Even though benzene is listed with an annual averaging period, because the activity periods are of a shorter-term nature it was thought that using 10% value of the TLV, or 160 µg/m³, would be an acceptable approach at defining an impact threshold.

Conclusions

Based upon this evaluation, air quality impacts from Alternative Sed-6 are predicted to be more extensive than those from Alternative Sed-4. The impacts will likely affect a larger area and longer periods due primarily to the dewatered area where dry excavation will be conducted. In addition, engineering and performance controls needed to control emissions from a large dewatered area are much more complex. As an example, emissions from dredging can be controlled substantially by stopping or modifying dredging activities; however, stopping excavation activity will not stop volatile emissions from a large area of exposed saturated sediment. Under some conditions the only recourse for controlling exposure to elevated levels of volatilized contaminants or odors under the Sed-6 Alternative may be temporary evacuation of area residents and businesses. The potential for more exposure to benzene and odor incursions are also greater due to the increase in Site schedule for Sed-6 of one to two or more years.

References

SERVICE. 2002. "Data Gap Report, Appendix A2 Sediment Sampling and Analysis for Air Emissions, St. Louis River/Interlake/Duluth Tar Site." Service Engineering Group. December.

URS. 2007. "Treatability Phase I Treatability Study Work Plan and Sampling and Analysis Plan-Ashland/NSP Lakefront Site." URS Corp., Ashland Wisconsin, Approved February.

URS. 2008. "Feasibility Study-Ashland/NSP Lakefront Superfund Site." Ashland Wisconsin, URS Corp., December 5.

Table B.1
Ashland/NSP Lakefront Site – Modeled Benzene Emission Rates –
Alternative SED-4 and Alternative SED-6

Modeled Source ID	Alternative SED-4 Wet Dredge Benzene Emission Rate (g/m²s)	Alternative SED-6 Dry Excavate Benzene Emission Rate (g/m²s)
1	2.05E-05	2.85E-05
2	2.05E-05	2.85E-05
3	8.59E-06	1.20E-05
4	4.58E-05	6.39E-05
5	2.82E-05	3.93E-05
6	2.82E-05	3.93E-05
7	4.09E-06	5.70E-06
8	6.38E-05	8.90E-05
9	1.38E-04	1.93E-04
10	4.94E-05	6.90E-05
11	2.15E-07	3.00E-07
12	1.74E-05	1.74E-05
13	1.77E-05	1.77E-05
14	1.76E-05	1.76E-05
15	1.31E-04	1.59E-04
16	5.80E-05	8.09E-05
17	2.37E-05	3.31E-05
18	2.37E-05	3.31E-05
19	3.40E-05	4.74E-05
20	1.68E-05	2.34E-05
21	3.59E-07	5.01E-07
22	2.40E-07	2.40E-07
23	8.92E-06	8.92E-06
24	9.17E-06	9.17E-06
25	2.21E-07	2.21E-07
26	1.73E-06	2.41E-06
27	8.42E-07	1.17E-06
28	7.98E-05	1.11E-04
29	8.59E-05	1.20E-04
30	1.86E-05	2.59E-05
31	1.13E-07	1.13E-07
32	3.89E-06	3.89E-06
33	1.35E-05	1.35E-05
34	1.72E-05	1.72E-05
35	8.86E-05	8.86E-05
36	9.50E-07	1.33E-06
37	5.16E-05	5.16E-05
38	4.33E-06	4.33E-06
39	3.87E-05	3.87E-05
40	2.79E-05	2.79E-05
41	8.84E-08	8.84E-08
42	2.76E-07	2.76E-07
dewater	2.13E-04	2.13E-04
stockpile	3.93E-05	3.93E-05
dewater2	1.14E-04	1.14E-04



Figure B.1. Ashland/NSP Lakefront Site – Alternative Sed-6 Dry Excavate Cell and Activity Areas



Figure B.2. Ashland/NSP Lakefront Site – Comparison of Alternative Sed-6 and Alternative Sed-4-Benzene 1/10th TLV Concentration Lines of 160 µg/m³



Figure B.3. Ashland/NSP Lakefront Site – Threshold Recognition Odor Units – Alternative Sed-4 and Sed-6

Attachment C

Ashland Memo, Technical Approach to Develop Performance Standards



Memorandum

April 3, 2009

TO: Scott Hansen, U.S. EPA
Jamie Dunn, Wisconsin DNR
Bill Fitzpatrick, Wisconsin DNR
Omprakash Patel, Weston Solutions

FR: Jerry Winslow, Northern States Power Company
Steve Laszewski, Foth
Nick Azzolina, Foth
Scott McCurdy, Cedar Corporation
Mitch Evenson, Cedar Corporation

RE: Proposed Technical Approach Summary – Performance Standard and Cover
Specifications for the Ashland/NSPW Lakefront Site

This memorandum outlines the proposed technical approach for the conservative design strategy used to develop the post-dredge Performance Standard and cover specifications at the Ashland/Northern States Power Company (NSPW) Lakefront site. This memorandum supplements the proposed approach outlined in the March 6, 2009 memorandum, and expands upon the Dredge Performance Decision Tree (Decision Tree) and Attachment A of that March 2009 document.

Design Basis

The Performance Standard is based on: removal of sediment to a specified target elevation, corresponding to the 9.5 mg/kg Preliminary Remediation Goal (PRG), and post-dredge sediment total PAH concentration protectively managed with backfill cover/habitat material placement. Ultimately, the goal is to develop numerical ranges in the Performance Standard and to design residual cover specifications that are protective of the benthic macroinvertebrate community.

The development of the Performance Standard and the design of the residual cover specifications relies upon published guideline documents from the U.S. Army Corps of Engineers, U.S. EPA, and the peer-reviewed scientific literature. This design process has been used successfully by the

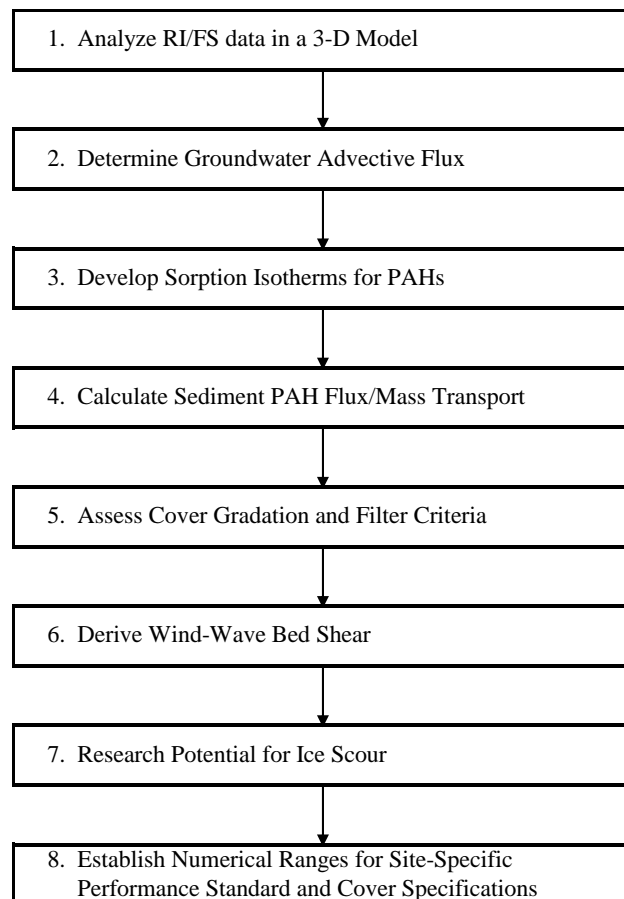
The information contained in this memorandum is considered privileged and confidential and is intended only for the use of recipients and Foth.

2737 S. Ridge Rd., Ste.600 PO Box 12326 Green Bay, WI 54307-2326 (920) 497-2500 Fax: (920) 497-8516

WDNR, U.S. EPA and Responsible Parties (RPs) at other locations within Region V (ERDC-EL 2008a, 2008b, GW Partners 2007, NRC 2007).

The following sequence of eight primary tasks summarizes the individual design elements being used to develop the Performance Standard and cover specifications (Figure 1). The remaining text provides details regarding the technical approach and references for a particular tasks.

Figure 1. Sequence of design tasks for Performance Standard and Cover.

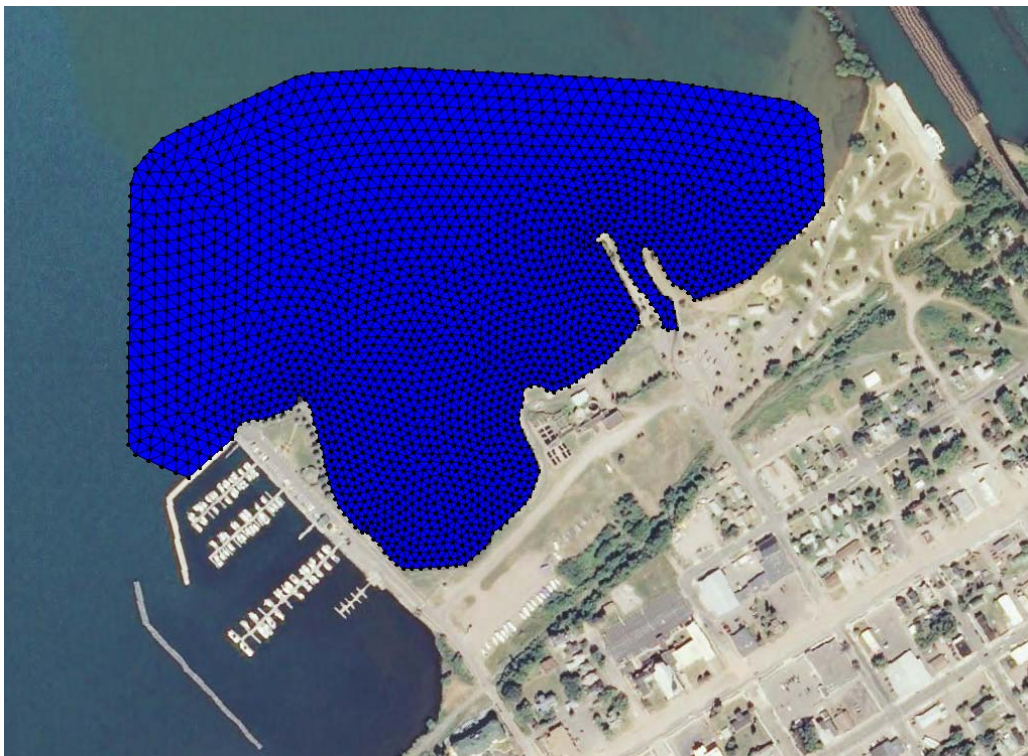


A full design document summarizing the remedial design work will be submitted as part of the U.S. EPA Superfund process. This memorandum provides a summary of the design tasks.

1. Analyze RI/FS data in a 3-D model

Accurate 3-D delineation of sediments is crucial for sediment assessment and remediation. Therefore, sediment data from the complete Remedial Investigation/Feasibility Study (RI/FS) database, consisting of 531 total PAH measurements (tPAH) and other data such as boring logs, grain size, percent solids, etc., were entered into GMS-SED 6.5.2 software (Aquaveo, LLC). GMS-SED is a commercially available finite-element mesh model. The GMS-SED package of stratigraphy modeling and geostatistics tools can be applied for modeling contaminated sediment deposits, and ultimately for delivery or communication of the sediment removal prism to a dredging contractor. Figure 2 depicts the Ashland GMS-SED model triangulated irregular network (TIN) domain, which consists of nearly 2,300 nodes.

Figure 2. Ashland GMS-SED model domain.



The sediment RI/FS tPAH data were then interpolated throughout the 3-D model domain using a geostatistical kriging routine in GMS-SED. Concentrations of tPAH are therefore known within the full 3-D model domain (areal and vertical extent), which can subsequently be used to determine dredge surfaces, post-dredge water depths and post-dredge or residual tPAH concentrations. The GMS-SED 3-D model provides the framework within which the sediment remedial design is developed.

2. Determine groundwater advective flux

An analysis of groundwater advection is important to provide an estimate for the potential for upward migration of PAHs through the Chequamegon Bay. Output from the advection analysis is subsequently used as input into the sediment PAH flux/mass transport calculations (Task 4).

Contour maps of potentiometric surfaces were taken from Figures 3-8 to 3-13 of the RI report dated August 31, 2007. The figures do not provide details for the stratigraphy of the sediment bed, particularly how a clay confining unit interacts with the beach sediments (sands). However, there was a very shallow hydraulic gradient (at depth) identified towards the bay for reviewed periods (June 15, 2005 and November 3, 2005). The water table map (June 15, 2005) showed only a 1% slope in the water table near the shoreline. Therefore, the groundwater discharge to the bay is likely minor.

It would be impractical to develop a model to estimate upflow through the sediment bed at this stage. If significant upflow is present, it is likely localized in areas of more permeable base materials. Therefore, direct measurement of hydraulic conditions beneath the impacted sediments is recommended during future stages of work.

While upflow was found to be minor, some assessment of the impacts of upflow of varying magnitudes will be incorporated when evaluating sediment PAH flux/mass transport (Task 4) through post-dredge cover material.

3. Develop sorption isotherms for PAHs

The sorption of sediment-bound PAHs is an important component to understanding the potential transport of post-dredge residual PAH concentrations through the cover material. The process by which organic compounds such as PAHs distribute themselves between solid and solution phases is called partitioning. Sorption isotherms describe this relationship, and a general equilibrium isotherm for PAHs is the nonlinear Freundlich sorption isotherm

$$q = K_F(C_{pw})^n$$

Equation 1

Where:

- q = Total sediment PAH (mg/kg);
- K_F = Isotherm coefficient (slope);
- C_{pw} = Porewater concentration (mg/L); and
- n = Isotherm coefficient (power)

The Freundlich sorption isotherm can be linearized, as shown in Equation 2:

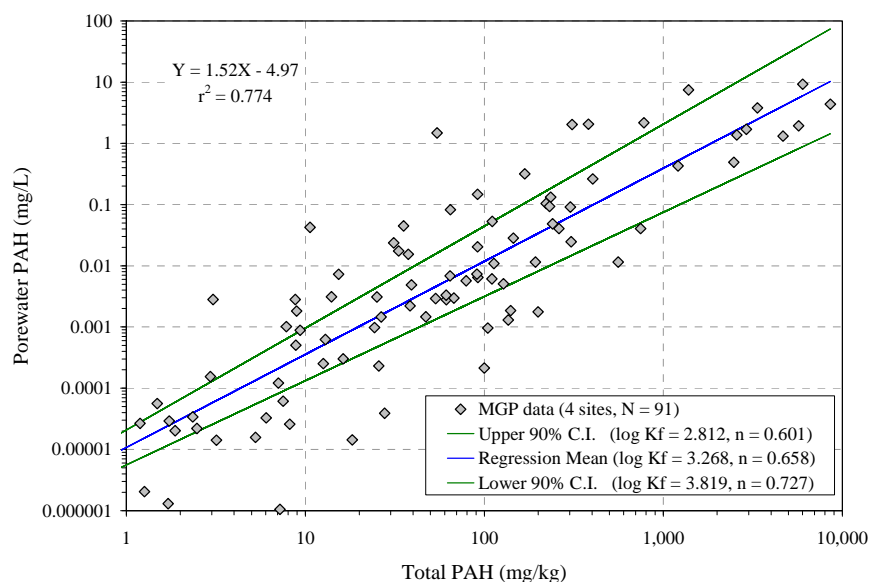
$$\log(q) = \log K_F + n \log(C_{pw})$$

Equation 2

A linear regression was used to determine the relationship between sediment total PAH and porewater measurements to derive an MGP Freundlich isotherm (i.e. K_F and n values). A data set of 91 sediment samples collected from four different MGP sites was used in the analysis.

The results of the regression fit and the 90 percent confidence interval for the slope and intercept were then used to develop the range in Freundlich isotherm coefficients (K_F and n). A plot of the regression fit is shown in Figure 3. These estimates were then directly input into Task 4.

Figure 3. Regression used to develop the Freundlich sorption isotherm.



4. Calculate sediment PAH flux/mass transport

Modeling for the post-dredge cover chemical isolation was done using numerical modeling for a diffusion-only case and for an advection-dispersion case to evaluate the maximum flux estimate of PAHs over time. Given that the PAH sediment-porewater partitioning is nonlinear, an analytical solution was not available. Instead, analytical solutions for linear partitioning were used to provide order-of-magnitude checks of the numerical solutions.

The diffusion-only model is a one-dimensional model, and was used to evaluate how different post-dredge cover thicknesses (e.g. 0.5 ft, 1 ft, 2ft, 3ft, etc.) provided a diffusive barrier, limiting the mass flux of the underlying sediment PAHs into the active benthic layer. Diffusion coefficients for the individual PAH compounds were taken from Eek et al. (2008). The mass diffusing is proportional to the gradient, and can be expressed using Fick's first law, in one dimension (Equation 3).

$$F = -D^* (dC/dx)$$

Equation 3

Where:

F	= mass flux of solute per unit area per time
D*	= effective diffusion coefficient (cm ² /yr)
C	= solute concentration (g/cm ³)
dC/dx	= concentration gradient (g/cm ³ /thickness in cm)

The selection of the effective diffusion coefficient (D*) was first based on conservative selection of a molecular diffusion coefficient and consideration of tortuosity effects. The effective diffusion coefficient for the sediment was estimated to be 107 cm²/yr.

Numerical modeling was conducted with Hydrus-2D software (PC Progress, Inc.). The Hydrus-2D program is a finite element model for simulating the movement of water, heat, and multiple solutes in variably saturated media (Simunek et al. 1999).

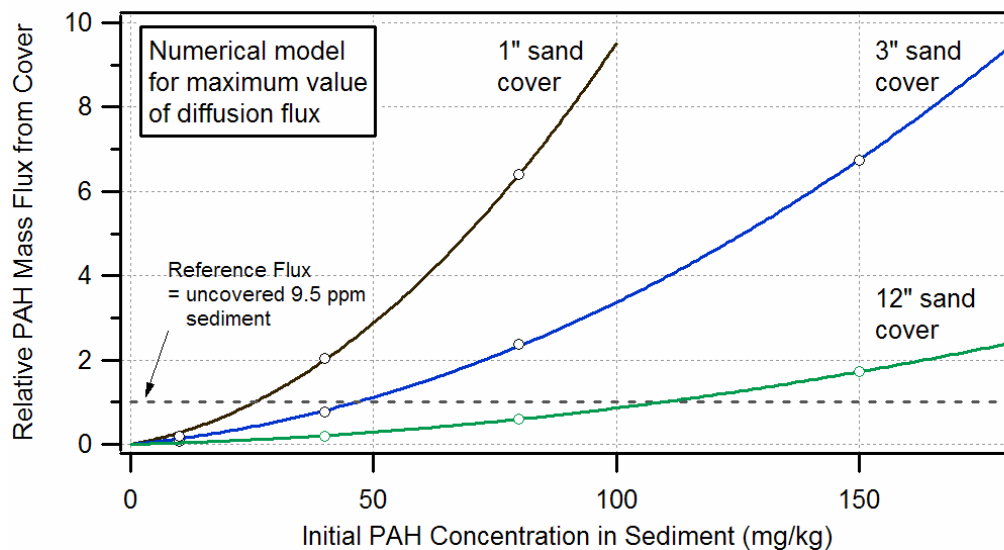
Numerical model estimates for PAH flux through a residual cover were made for various input levels, for initial sediment PAH concentrations of 10, 40, 80 and 150 mg/kg, and for cover thicknesses of 0, 1.0, 3.0, and 12.0 inches of sand. The maximum PAH mass flux from an uncovered (0-inch sand thickness) sediment with a PAH concentration of 10 mg/kg was considered a reference flux. Residual sand covers significantly reduced the modeled PAH mass flux relative to the reference condition. The effects of sand cover on the diffusion flux are shown in Figure 4. The model results show that the maximum flux from a 3-inch sand cover over residual sediment with a PAH concentration of 50 mg/kg is roughly equivalent to the flux from uncovered sediment with a PAH concentration of 9.5 mg/kg. For a 12-inch sand cover, residual sediment with a PAH concentration of 100 mg/kg is roughly equivalent to the flux from uncovered sediment with a PAH concentration of 9.5 mg/kg.

A significant reduction in PAH mass flux as a result of sand covers is consistent with recent literature on the subject. For example, Eek et al. (2008) showed that 1 cm (0.4 in) of sand effectively reduced PAH mass flux from an Oslo Harbor sediment to only 3.5 – 7.3% of the uncapped sediments. Herrenkohl et al. (2001) provided a survey of field and lab studies which show effective chemical isolation, and, with the results of a lab study of consolidation over a PAH and NAPL-contaminated sediment from the Wyckoff / Eagle Harbor Superfund site,

showed that the sand effectively isolated PAH contamination away from the top 10 cm (the zone of sand normally considered the biologically active or bioturbation zone).

It is important to note that the results of modeling are conducted not to cover undredged sediment with high PAH concentrations, but to appropriately manage residual sediments that are likely to result from dredging using current best practices. In addition, considerations of effective isolation from advection and residual concentrations are best reviewed with respect to site specific conditions and effective implementation of the overall remedy.

Figure 4. Effects of Sand Cover on Diffusive Mass Flux from Residual Sediment



Summary of sediment PAH flux/mass transport evaluation:

- ♦ Sand cover effectively reduces sediment PAH flux to the benthic layer;
- ♦ Different sand cover thicknesses address variable post-dredge residual concentrations;
- ♦ Since sand cover effectively protects the benthic layer, the engineering design challenge is to insure that residual cover remains in place by assessing post-dredge bathymetry, cover gradation and filter criteria (Task 5), and accurately deriving wind-wave bed shear (Task 6).

5. Assess cover gradation and filter criteria

Gradation and filter details are necessary to insure that residual cover remains stratified over time and to prevent erosive losses from poorly matched post-dredge sediment and cover media.

The RI/FS sediment grain size distributions were evaluated using the method of moments (McBride 1971) to determine the 50th and 85th percentile values (d_{50} and d_{85} , respectively) in millimeters. The d_{50} and d_{85} for sediment samples collected at depths greater than 1 foot were determined to range from 0.1 to 0.2 mm and 0.2 to 0.4 mm, respectively.

Given these characteristics of the material at depth, it was determined that a sand cover with a d_{50} of approximately 0.8 mm would remain sufficiently stratified by the underlying sediment and could therefore be used for post-dredge cover material (Cedergren 1989).

Depending on the results of the wind-wave sediment bed shear stress (Task 6), armoring of the post-dredge cover may or may not be necessary. If large stone (3 to 3.5 in) armor is necessary, then an intermediate gravel layer will be required between the sand cover and the armor stone to both allow for adequate filter and provide the necessary strength to support armor. The specifics of the final cover specifications will therefore ultimately depend upon final water depth and the location of any armored cover.

6. Derive wind-wave bed shear

Numerical modeling and analyses to estimate peak bed shear stresses at the Ashland/NSPW Lakefront Site using the MIKE21 model in order to derive estimates of shear stresses due to wind-generated waves and circulation is underway. The goal of the wind-wave modeling is to evaluate a projected post-remedy bathymetric condition and estimate shear stresses under conservative wave and water depth conditions. Wind-wave bed shear estimates provide additional confidence in residual cover specification and placement.

MIKE21 is a commercial modeling system developed by the Danish Hydraulic Institute that has been widely applied by Baird at project sites both on the Great Lakes and worldwide. The specific modules to be applied will include the MIKE21 Spectral Wave (M21SW) model to simulate wind-wave growth, transformation and dissipation, and the MIKE21 Flexible Mesh Hydrodynamic (M21FM) model to simulate wind-induced current flow.

The numerical models will be run for the various test cases identified using the GMS-SED 3-D model using various post-dredge/cover bathymetric scenarios. Inputs to the M21SW model will consist of the bathymetric grid, and a steady-state wind speed and direction. The model will provide as output estimates of wave height, period and direction, as well as lakebed shear stress, throughout the model domain. The identical inputs will be provided to the M21FM model, which will produce as output estimates of water level variation, current speed and direction, and current-induced bed shear stress.

A scenario representing conservative wave and water depth conditions will be identified from the various test cases for use in subsequent modeling. These conditions will be checked relative to known site conditions, so the selected conditions are indeed appropriately conservative. Results of the wind-wave modeling will be used to evaluate selection of residual cover specifications determined through Tasks 1 through 5 above.

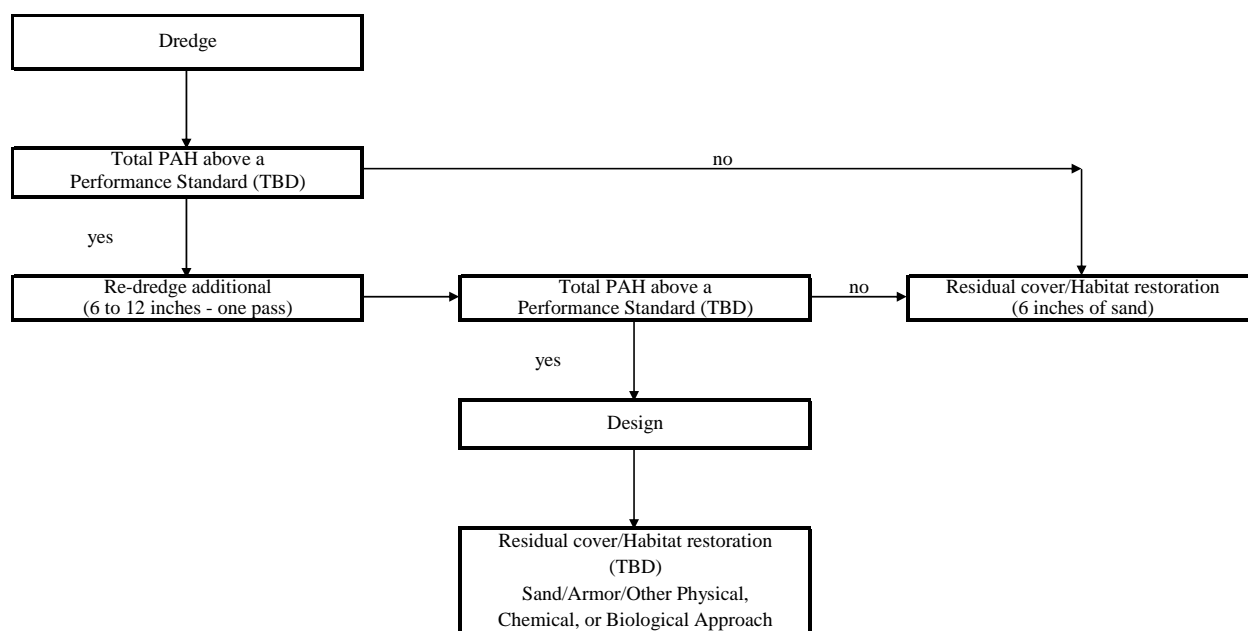
7. Research potential for ice scour

Seasonal freeze and thaw cycles of bay water can produce ice that may contact the post-dredge residual cover/habitat restoration layer. The probability of contact between ice and the remediated surface will be assessed in conjunction with determination of final water depth. Assessment will incorporate historical climatic variation and resulting ice thickness. Shoreline effects will be considered separately and used in design of final shoreline construction.

8. Establish numerical ranges for site-specific Performance Standard and cover specifications

The March 6, 2009, memorandum provided a proposed Dredge Performance Decision Tree, shown below as Figure 5 with the addition of the design element.

Figure 5. Proposed Dredge Performance Decision Tree



A key component of the Decision Tree is the link between the post-dredge tPAH Performance Standard and subsequent residual cover/habitat restoration or design decision. An adaptive management strategy which allows for a numeric range in the Performance Standard, derived using site-specific information and the rigorous, scientifically based methodology described above, is integral to selecting the appropriate sequence of steps within the Decision Tree.

Proposed next steps

The proposed next steps include:

- ♦ Meeting or call of a Work Group consisting of Agency and NSPW representatives to evaluate developing the March Technical Memorandums, this April Memorandum, the Performance Standard, and elements of the 2010 Pilot Project.
- ♦ Consensus between the Agencies and NSPW on the above technical approach for developing the Performance Standard.
- ♦ Conductance of specific work items to supplement the approaches.

References

Cedergren, H.R., 1989. Seepage, Drainage, and Flow Nets, 3rd edition. John Wiley & Sons, New York.

Eek, E., Cornelissen, G., Kibsgaarda, A., and Breedveld, G.D., 2008. Diffusion of PAH and PCB from contaminated sediments with and without mineral capping; measurement and modeling. *Chemosphere*, Volume 71, Issue 9, April 2008, Pages 1629-1638.

ERDC-EL, 2008a. *The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk*. U.S. Army Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory. January 2008.

ERDC-EL, 2008b. *Technical Guidelines for Environmental Dredging of Contaminated Sediments*. U.S. Army Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory. September 2008.

GMS-SED, 2005. *GMS-SED Version 6.0, AQUAVEO Water Modeling Solutions*, South Jordan, Utah.

GW Partners, LLC, 2007. *OUI Design Supplement, Lower Fox River Operable Unit 1*. Prepared for GW Partners, LLC, by Foth Infrastructure & Environment, LLC, and CH2MHill, Inc. November 2007.

Herronkohl, M.J., J.D. Lunz, R.G. Sheets, and J.S. Wakeman. 2001. Environmental Impacts of PAH and Oil Release as a NAPL or as Contaminated Pore Water from the Construction of a 90-cm In Situ Isolation Cap. *Environmental Science & Technology*, 35(24): 4927-4932.

McBride E.F. Mathematical treatment of size distribution data, in R.E. Carver (ed.), *Procedures in sedimentary petrology*. ©1971 by John Wiley & Sons, Inc. Table 2, p. 119.

NRC, 2007. *Sediment Dredging at Superfund Megasites: Assessing the Effectiveness. Committee on Sediment Dredging at Superfund Megasites*. National Research Council of the National Academies. Washington, D.C.

Simunek J., Sejna M., and van Genuchten M. Th. 1999. The Hydrus-2D software package for simulating two-dimensional movement of water, heat, and multiple solutes in variably saturated media. Version 2.0, IGWMC - TPS - 53, International Ground Water Modeling Center, Colorado School of Mines, Golden, Colorado, 251pp., 1999.